§24. Simulation Study of Fusion Ignition in LHD-type Helical Reactor Due to Joule Heating

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i) Configuration with D-shaped magnetic surface generated by the geodesic winding helical coils. To realize fusion reactors at an early stage, it is necessary to mitigate the severe engineering issues, by innovative concept of core plasma physics. We have proposed a geodesic winding helical reactor with D-shaped magnetic surface [1]. The geodesic winding D-shaped helical magnetic field configuration has the following merits.

- The geodesic winding allows the tightening winding of the helical coils. The helical coil winding is expected to be mechanically stable and easy to manufacture.
- The stability of the magnetic surface position, including the divertor leg structure.
- The stability of high-beta and high-density plasma because of the magnetic well in the core plasma region and the high magnetic shear in the peripheral region.
- The improvement in confinement because of the large plasma volume and D-shaped magnetic surface.
- Large horizontal ports can be set up in the geodesic winding D-shaped helical magnetic field configuration.

The confinement improvement using the plasma current driven by magnetic-axis position shift is studied for the ignition of high density helical plasma [2]. Figure 1 shows an example of D-shaped magnetic configuration.

ii) Numerical study of fusion ignition of reduced-size helical reactor. As an example of the reduce-size reactor, fusion ignition of the helical reactor shown by Fig. 1 is studied numerically. Over 190 seconds, magnetic field configuration is shifted to the optimum one from a outer-shifted magnetic-axis equilibrium configuration. The IV coil current is increased 65.1 kA and finally reaches asymptotically to the optimal value, 129.5 kA. Plasma current 12.6 MA is driven during this time, by magnetic flux change of IV coils. Numerical results are shown in Fig. 2.

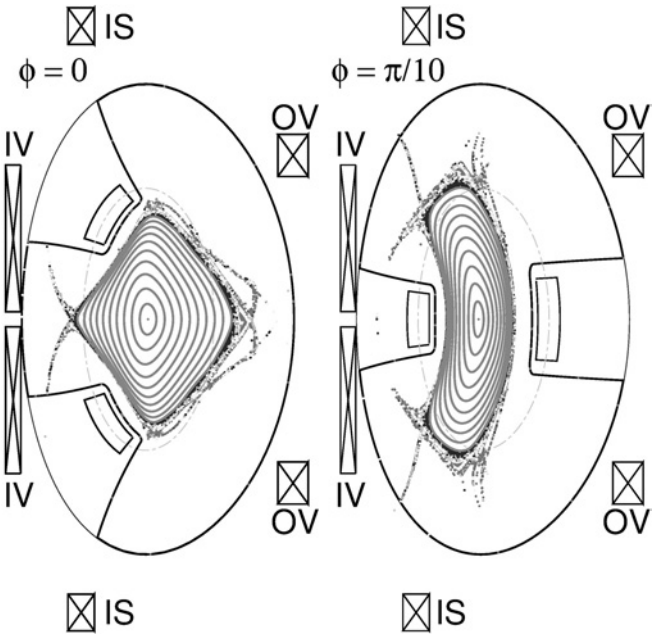

Fig. 1: Magnetic configuration with IV coils close to the plasma column. Plasma current is driven by the magnetic-axis position shift using current control of the IV coils.

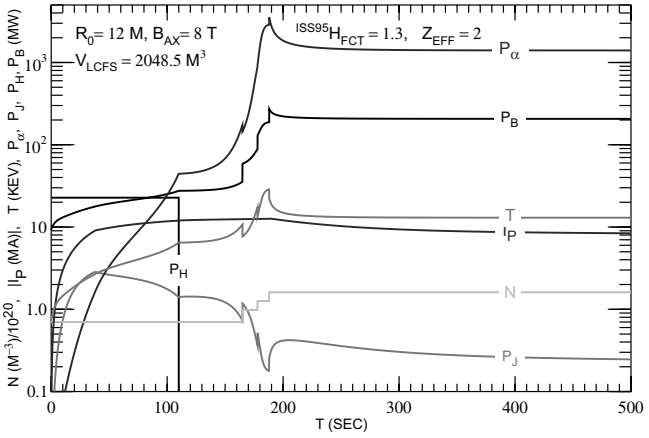

Fig. 2: Fusion ignition using the current drive by magnetic-axis position shift of D-shaped magnetic surface configuration generated by the geodesic winding helical coils.

1) T.Watanabe, Reduced-Size LHD-Type Fusion Reactor with D-Shaped Magnetic Surface , (PFR. 7, 2403113-1-5 (2012)).

2) T.Watanabe, DT fusion ignition of the LHD type helical reactor by Joule heating associated with the magnetic axis position shift (PFR, 6, 2101055 (2011)).